3. "Experimental Researches in Electricity." Twenty-sixth Series. On Magnetic Conducting Power and Atmospheric Magnetism. By Michael Faraday, Esq., D.C.L., F.R.S. &c. Received October 9, 1850.

The remarkable results respecting oxygen and nitrogen described in the last Series, and the absence of any change of volume under strong magnetic action, led the author to apply for a time the idea of conducting power to the magnetic phenomena there described, meaning by that phrase the capability which bodies possess of affecting the transmission of the magnetic force without any reference to the process by which that transmission is effected; and assuming that two bodies are at the same time in the magnetic field, and that one displaces the other, he considers the result as a differential effect of their difference in conducting power.

If a free portion of space be considered with lines of equal magnetic force passing across it, they will be straight and parallel lines. If a sphere of paramagnetic matter be placed in such a space, they will gather upon and in the sphere, being no longer parallel in their course, nor of equal intensity in every part; or if a sphere of diamagnetic matter replace the former sphere, the lines of force will open out where the sphere is, being again no longer parallel in direction nor uniform in force. When the field of magnetic force is formed between the opposite flat ends of two large magnetic poles, then these are affected, and the globes also, and there are mutual actions; a paramagnetic body, if a little elongated, points axially and tends to go to the iron walls of the field, whilst a similar diamagnetic body points equatorially, and tends to go to the middle of the field. Paramagnetic bodies repel each other, and so also do diamagnetic bodies; but one of each class being taken, they attract one another.

The convergence of the lines of force upon the opposite sides of the paramagnetic sphere, and the corresponding divergence of them on the opposite sides of the diamagnetic sphere, the author expresses by the term *conduction polarity*. This polarity he carefully distinguishes from that which depends upon the reversion of the direction of the power; the latter he considers as a property of the particles of magnetic matter; the former as dependent rather upon the action of the mass: the latter is an absolute inversion of the direction of the power, the former only a divergence or deflection of it.

Applying the idea of conduction to magnecrystallic bodies, he concluded that the magnecrystallic axis would coincide with the direction of better conduction, and thence concluded, that, if a symmetric crystal of bismuth were carefully examined in different directions, it would be found to be less diamagnetic when its magnecrystallic axis was perpendicular to the axis of magnetic force of the field in which it was to be submitted to experiment, than when it was parallel to the magnetic axis. By means of the differential torsion balance described in the former paper, he was able to make the trial, and found the results were as anticipated. With calcareous spar and his present balance he was not able to establish any difference, but concludes that it will prove most diamagnetic when the

optic axis of the crystal and the magnetic axis of the field are parallel.

Advancing to the consideration of atmospheric magnetism, the author first refers to the earth as a source of magnetic power from which emanate lines of magnetic force passing into space according to a particular but recognized distribution, and in obedience to the general laws which govern the distribution of power about a given irregular magnet. In pure space the magnetic power is considered as transmitted onwards with a certain degree of facility which is constant, but may be increased or diminished by the presence of paramagnetic or diamagnetic matter within that space. The atmosphere is a portion of such matter, and can affect the magnetic lines which pass from the earth into space, and affects them differently according to variations which continually occur in it under natural circumstances. Four-fifths nearly by volume of the air is nitrogen, which is a gas that neither under any difference of temperature or of expansion shows any alteration in its power of affecting the transference of the magnetic force; whether added to space therefore in one state or another, or when undergoing changes of a corresponding kind by natural cause, it has no influence on the magnetic force. The perfect identity in magnetic action of hot and cold nitrogen, the author proves by new and delicate experiments. Oxygen forms the remaining fifth of the atmosphere. Its great magnetic changes by expansion have been described in the Twenty-fifth Series. Those produced by difference of temperature were described in the Philosophical Magazine for 1847, but are now resumed with more care, and found to belong to it alone, and not to nitrogen or to carbonic acid: as its temperature is raised its paramagnetic force diminishes, being resumed as the temperature falls again. These properties it carries into the atmosphere, so that the latter is in reality a magnetic medium ever varying, from the influence of natural circumstances, in its magnetic power. If a mass of the air be cooled it becomes more paramagnetic, if heated it becomes less paramagnetic (or diamagnetic), as compared with the air in a mean or normal condition.

The effect of the approach and retreat of the sun in his daily course is to produce such variations of changes in the temperature and expansion of the atmosphere as to influence the lines of force emanating from the earth, both in their direction and intensity; and the manner in which this influence will be developed is by means of figures and descriptions stated by the author in relation to the annual and daily variation, and the irregular perturbations of the magnetic force, which he thinks are consequences of it. He then applies the result of the magnetic observations at Hobarton as a test of the probable truth of the hypothesis, and considers that it affords strong confirmation. The upper or north end of the needle there goes west until about twenty-one o'clock, whilst the dip increases; the dip still increasing until noon, the upper end returns rapidly eastward, as the sun passes by, until two o'clock, the dip then decreasing; after which the needle goes west again, following the

sun. On examining the results at Toronto, corresponding effects were found to occur, when the upper or south end of the needle was considered, and therefore in accordance with the hypothesis. The examination of the observations made at Greenwich, Washington, Lake Athabasca, Fort Simpson, and St. Petersburgh, are considered as further adding confirmation. By the aid of these observations the author restates his principles more minutely, endeavouring to indicate what difference, changes in the inclination, declination, place of the sun, land, and sea, &c. will produce.

Though the sun is the cause of those changes in the atmosphere which affect the lines of force of the earth, he is not assumed as the centre of action as regards those lines; that is considered to exist somewhere in the atmosphere. It appears to be in the upper regions and not on the surface of the earth, because it increases the dip of places north and south of the tropics which have a certain amount of inclination, as at Hobarton and Toronto, both in summer and winter, but it diminishes the dip at places which are within the tropics, and with little inclination, as St. Helena. By other kinds of observations, it appears to be in advance of the sun. All the phenomena indicate that the sun does not act directly on the needles at different places, but mediately through its effect on the atmosphere.

The author then considers the possible cause of numerous irregular variations, such as those that are shown by the photographic processes of record at Greenwich and Toronto. The varying pressure of the atmosphere, the occurrence of winds and large currents of air, of rain and snow, of the passage of those masses of warm and cold air which the meteorologist recognizes in the atmosphere, of the aurora borealis, he considers may all produce changes in the lines of magnetic force, and become more or less sensible in the records of irregular variations. The author thinks it very possible that masses of air at different temperatures may be moved by the magnetic force of the earth, according to the principles of differential action made manifest in the experiments on warm and cold oxygen, in which case material as well as potential magnetic storms may exist. He concludes his paper by calling attention to the wonderful constitution of oxygen in its magnetical and electrical, as well as its chemical relations, to the offices it has to perform as part of the atmosphere.

4. "Experimental Researches in Electricity." Atmospheric Magnetism, continued. Twenty-seventh Series. By Michael Faraday, Esq., D.C.L., F.R.S. &c. Received November 19, 1850.

In order to obtain an experimental representative of the action of the atmosphere when heated above or cooled below the average temperature, the author employed a ring helix of covered copper wire, through which an electric current was passed. The helix was about one inch and a half in diameter, and having the well-known system of magnetic forces, was placed with its magnetic axis parallel to a free needle: when its position was such that a needle within the ring would point with the north end downward, then the effect in deflecting the surrounding lines of force of the earth was considered